AMENDMENTS TO THE CLAIMS

Please amend the claims as follows:

Claims 1-10 (withdrawn)

11.(currently amended) A quad compensated clock for use in a borehole, said quad compensated clock comprising:

(a) a quad compensated resonator comprising four oscillator crystals

(i) electrically connected in series with their acceleration sensitivity vectors aligned, nominally one per quadrant, in a common plane, and

(ii) configured in pairs so that maximum acceleration sensitivity vectors of oscillators comprising said pairs are in opposite directions; and

(b) oscillator circuitry cooperating with said quad compensated resonator;

(c) a quad compensated temperature sensor; and

(d) a processor; wherein

(~~c~~e) outputs of said oscillator crystals in said quad compensated resonator are combined and input to said oscillator circuitry to form a quad compensated clock output with reduced sensitivity to acceleration; and

(~~d~~f) during a predetermined time interval, said quad compensated clock output is combined with output from ~~a~~ said quad compensated temperature sensor using a compensation algorithm resident in ~~a~~ said processor cooperating with said clock, to correct said quad compensated clock output for variations in crystal properties.

12.(original) The clock of claim 11 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

13.(previously amended) The clock of claim 11 wherein said crystal properties comprise:

(a) crystal aging;

(b) crystal hysteresis;

(c) crystal warm-up; and

(d) crystal short-term and long-term frequency stability characteristics.

14.(original) The clock of claim 11 further comprising packaging for said quad compensated resonator and said cooperating oscillator circuitry, wherein said packaging comprises insulation to reduce sharp temperature fluctuations and thermal transient effects in said quad compensated resonator and said cooperating oscillator circuitry.

Claims 15-21 (withdrawn)

22. (currently amended) A method for measuring time from within a borehole, the method comprising;

(a) providing an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals;

(b) configuring said oscillator crystals in each said quad compensated clock to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator;

(c) combining outputs of said oscillator crystals in said quad compensated resonator to form a quad compensated clock output;

(d) using a compensation algorithm resident in a processor cooperating with said quad compensated resonator, combining each said quad compensated clock output thereby correcting said quad compensated clock output for changes in response properties of said crystals; and

(ee) selecting said configuration and said combination of outputs of said oscillator crystals to reduce effects of acceleration upon said quad compensated clock output.

23.(previously amended) A method for measuring time from within a borehole, the method comprising:

(a) providing an ensemble of quad compensated clocks, each said quad compensated clock comprising four oscillator crystals;

(b) configuring said oscillator crystals in each said quad compensated clock to a sensitivity vector of each said oscillator crystal to form a quad compensated resonator;

(c) combining outputs of said oscillator crystals in said quad compensated resonator to form a quad compensated clock output; and

(d) selecting said configuration and said combination of outputs of said oscillator crystals to reduce effects of acceleration upon said quad compensated clock output: wherein.

(e) said ensemble comprises four said quad compensated clocks; and

(f) each said quad compensated clock output from each said quad compensated clock are combined to yield ~~an~~ a quad compensated ensemble crystal oscillator clock output exhibiting less frequency drift as a function of time than any one said quad compensated clock in said ensemble.

24.(original) The method of claim 23 further comprising:

(a) providing a quad compensated temperature sensor; and

(b) combining output of said quad compensated temperature sensor with said quad compensated clock outputs to minimize effects of temperature upon said quad compensated ensemble crystal oscillator clock output.

25.(original) The method of claim 24 further comprising:

(a) processing each said quad compensated clock output with an optimization algorithm; and

(b) processing two or more said quad compensated clock outputs from said ensemble with a time-scale algorithm.

26.(original) The method of claim 25 further comprising correcting, using said optimization algorithm, each said quad compensated clock output for effects of:

(a) aging;

(b) hysteresis;

(c) crystal warm-up; and

(d) short-term and long-term frequency stability characteristics, considering statistical independence of said quad compensated clocks.

27.(original) The method of claim 25 further comprising, using said time-scale algorithm:

(a) assuring that three or more said quad compensated clocks of said ensemble provide statistical separation capability;

(b) if measurement noise of said quad compensated ensemble crystal oscillator system is small, providing means for calculating a time difference between any two said quad compensated clocks in said ensemble using time differences taken simultaneously between adjacent said quad compensated clocks;

(c) providing stochastic performance parameters which allow optimum estimate of time, frequency, relative frequency drift, and a weighting factor for each of the said quad compensated clocks in said ensemble;

(d) if a said quad compensated clock has abnormal behavior over a measurement cycle, de-weighting of that clock so that the quad compensated ensemble crystal oscillator system output is not degraded;

(e) if time errors correlate with temperature changes measured by said quad compensated temperature sensor, using this correlation to upgrade a temperature profile model resident within said time-scale algorithm;

(f) based upon operational environment changes sensed by one or more external environmental sensors, adaptively changing appropriate algorithms within said time-scale software; and

(g) providing said quad compensated ensemble crystal oscillator clock output

28.(original) The method of claim 27 wherein said quad compensated ensemble crystal oscillator clock output is frequency stable to less than about 3×10^{-9} and over a temperature range of 0 to 185 °C.

29.(original) The method of claim 24 further comprising calibrating said system to a reference frequency.

30.(original) The method of claim 23 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

31.(original) The method of claim 24 wherein said quad compensated temperature sensor comprises oscillator crystals having a temperature stability of about ±4500 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

32.(previously amended) A method for measuring time from within a borehole using a quad compensated clock, said method comprising:

(a) forming a quad compensated resonator by

(i) providing four oscillator crystals,

(ii) electrically connecting said four oscillator crystals in series with their acceleration sensitivity vectors aligned, nominally one per quadrant, in a common plane, and

(iii) configuring said crystal oscillators in pairs so that maximum acceleration sensitivity vectors of oscillators comprising said pairs are in opposite directions;

(b) providing oscillator circuitry cooperating with said quad compensated resonator;

(c) providing said measure of time by combining outputs of said oscillator crystals in said quad compensated resonator and inputting to said oscillator circuitry to form a quad compensated clock output with reduced sensitivity to acceleration; and

(d) during a predetermined time interval, combining said quad compensated clock output with output from a quad compensated temperature sensor using a

compensation algorithm resident in a processor cooperating with said clock to correct said quad compensated clock output for variations in crystal properties.

33.(original) The method of claim 32 wherein said quad compensated resonator comprises oscillator crystals having a temperature stability of about ±20 parts per million over a temperature range of about 0 to 180 degrees Centigrade.

34.(previously amended) The method of claim 32 wherein said variations in crystal properties comprise:

(a) crystal aging;

(b) crystal hysteresis;

(c) crystal warm-up; and

(d) crystal short-term and long-term frequency stability characteristics.

35.(original) The method of claim 32 further comprising disposing said quad compensated resonator and said cooperating oscillator circuitry within packaging which is insulated to reduce sharp temperature fluctuations and thermal transient effects in said quad compensated resonator and in said cooperating oscillator circuitry.

Claims 36-38 (withdrawn)